of the climate and soil to the crop of barley, particularly as to its brewing qualities.

RELATION OF CEREAL CROPS TO CLIMATE AND SOIL.

By Prof. T. L. Lyon.

(1) Modifications in cereal crops induced by changes in their environment.

Experiment and observations show that modifications occur in plants when carried from one environment to another.

These modifications affect the habits of growth and the yield and quality of grain.

Immediate modifications due to the definite effect of environment.

Permanent modifications accounted for by transmission of previously modified characters.

Modifications sufficient to form new strains or varieties. They become more pronounced each succeeding year until they come into equilibrium with the environment.

The same environment may produce different modifications in different plants.

The influence of previous environment in reference to variety testing.

The influence of previous environment on the practise of changing seed.

Productiveness and quality of grain not directly correlated.

There would seem to be an optimum development of vegetative portion of the plant for each environment, in order to produce a maximum of grain.

(2) The relation of wheat to climate and soil.

(a) Influence of climate upon yield and composition.
- A fairly cool, moist growing season favors a large yield of grain.
- A hot, dry growing season favors a high nitrogen content by arresting the development of the kernel.
- A hot, dry growing season also favors a large accumulation of nitrogen by the plant on a soil rich in nitrogen.

(b) Influence of soil upon composition and yield.
- Incomplete maturation produces high nitrogen content on manured soils.
- A poor soil may produce a wheat high in nitrogen thru failure to mature the crop.
- Nitrogenous fertilizers may slightly increase the percentage of nitrogen in wheat.

(c) Influence of soil moisture upon composition, yield, and and length of growing period.
- A concentration of the soil solution increases the percentage of nitrogen in the grain, and permits of rapid growth and early blooming.
- An insufficient supply of soil moisture prevents complete maturation of the crop and thus shortens the growing period.

(d) Conditions affecting the accumulation of nitrogen by the grain, or the yield of nitrogen in grain per acre.
- The supply of available nitrates and other plant food materials.
- The degree of concentration of the soil solution.
- The rate of transpiration.

(e) The conditions under which hard wheat is produced.
- Yellow berries in hard wheat.

(f) Improvement in yield accompanied by lower nitrogen content.

(3) The relation of corn to climate and soil.

(a) Influence of climate upon yield.
- Relation of heat units to length of growing period.
- Relation of yield to length of growing period.
- Relation of temperature to tillering.
- Relation of color of grain to climate.

(b) Influence of soil.
- Relation of tillering to available fertility.
- Relation of barren stalks to available fertility.
- Effect of available nitrogen on composition of kernel.

(c) Influence of soil moisture.

WEATHER BUREAU MEN AS EDUCATORS.

Classes from schools and colleges have visited the Weather Bureau offices to study the instruments and equipment and receive informal instruction, as reported from the following stations:

Dubuque, Iowa, May 18, 1907, about a hundred students from the Iowa State Normal School at Cedar Falls.

Honolulu, Hawaii, May 17 and 22, 1907, the physical geography section of the freshman class of Oahu College, in two divisions.

Little Rock, Ark., May 1 and 2, 1907, the physical geography class of the Little Rock High School, in two sections.

Reno, Nev., May 29, 1907, the physical geography class of the Reno High School.

Syracuse, N. Y., May 11, 1907, the physical geography class from the Warners, N. Y., High School.

THE COLD SPRING OF 1907.

By A. J. Henry, Professor of Meteorology. Dated June 24, 1907.

The record of temperature for a year is made up of varying periods of increasing and diminishing heat. In spring the successive increments of heat are offset in a measure by incursions of cold northerly winds. These interruptions to the normal annual march of the temperature ordinarily last two or three days, sometimes a week, much less frequently a month, and in extraordinary cases, two months or more, as in the case of the present year.

The length of the cold spell in the south was about two months; in the northern part of the country east of the Rocky Mountains, about seventy-five days. At this writing, June 24, unseasonably cold weather prevails in southern Idaho, Nevada, and Utah, a part of the country exempt from the cold of April and May.

During the progress of the cold weather it was observed, first, that areas of low pressure had almost completely forsaken the main path which follows along the northern boundary to the Lake region and thence down the St. Lawrence Valley; second, that instead of following the northern route, they moved from the southwest to the New England coast, and there remained stationary for several days, meanwhile increasing in strength, and causing a succession of northeast to northwest winds with snow or rain over the whole of New England, the Middle Atlantic States, and as far west as Indiana and the upper Lake region. This departure from the usual behavior of lows continued thruout April.

In May and June the lows were mostly in the form of barometric troughs, which, developing in the far west, were continually crowded a little to the south, so that the northern portions of the respective troughs, instead of passing down the St. Lawrence Valley, generally past east-southeast over the Middle Atlantic States and the ocean south of New England. A movement in this direction holds the winds of New England and the Middle Atlantic States continually in a northerly quarter.

In June, lows from the Southwest, after reaching the Ohio Valley, were effectively blocked in their northeastward course, the result being the formation of secondary disturbances off the Virginia coast, which moved slowly northeastward over the ocean, and thus kept the wind in a northerly or northeasterly quarter over the northeastern portion of the United States. It was not until the middle of June that the prevailing high pressures in the north began to weaken, thus paving the way for southerly winds and warm weather.

Two broad principles in regard to the influence of pressure distribution on the wind may be here enumerated, viz, high pressure in the northern interior, especially over the Dakotas, causes northerly to westerly and relatively cool winds over the districts both south and east; low pressure over northern districts and the interior valleys and high pressure in the southeast causes warm southerly winds at all times. There are a few minor exceptions, but in general the control of the weather can be referred to the pressure distribution which in turn controls the winds.

The difficulty in the practical application of these principles lies in the fact that nearly half of the North American Continent is *terra incognita* from a meteorological viewpoint. Nothing is yet known as regards the barometric conditions which prevailed in the interior of Cânada during the recent cold weather in the United States. The Weather Bureau has accumulated about a third of a century's observations and computed from them systems of normal pressure, temperature, etc. The next logical step is to examine the departures from the normal systems which occasionally form so marked a characteristic of the seasons. The foundation for this study, which must of necessity be most comprehensive, is now being laid; and the work is progressing in order. The underlying causes of the recent cold weather are probably obscure and deep seated. The incentive to discover them is as great as at any previous time in history, and the efforts of many men in many countries are now directed with that end in view.

A set of four charts has been prepared to illustrate the distribution of atmospheric pressure, the resultant winds, and the departure of the mean temperature from the normal for the warm month of March and the cold month of April, 1907. The main point of interest in these charts is the shifting of the area of high pressure from the Southeastern States in March to the Northwestern States in April, and, in consequence, the complete reversal of the winds and temperatures in April as compared with March. (See Charts IX and X, figs. 1–4.)

In this country within the last century there have been one remarkably cool summer, two periods of sixty days or more of cold weather in the late spring (one in 1857 the other in 1907), and a damaging frost in June, 1859, all of which will be briefly discust in the following remarks:

The cold summer of 1816.—Tradition and record both point to 1816 as the coldest continuous spell of summer weather ever experienced in this country. Dire accounts of the unseasonable weather of that year are probably familiar to most persons, but, unfortunately, the complete story of the year has not been told. The writer has collected the record of thermometric observations made in the United States from April to September, 1816, and presents them in Table 1. For comparative purposes similar records for more recent years, especially for the spring of 1857 and April and May, 1907, have been added.

There was nothing out of the ordinary in the winter and autumn of 1816, but beginning in April it was noted that the season did not advance with its accustomed celerity. May was unseasonably cool, but, as may be gleaned from the few comparative means available, not much worse than May of 1907. The culmination of untoward conditions appears to have been reached in the fore part of June, when there seems to have been a depression of temperature attended by snow and ice in the St. Lawrence Valley, northern New York, and northern New England, which was then, and still is, unparalled for the season. Probably the most severe phase of the weather is illustrated by a correspondent of the Boston Recorder, who, writing from Hallowell, Me., under date of June 12, 1816, says:

> There has not been within the memory of the oldest inhabitants nor probably since the first settlement of the country such weather in June as for the week past. On Thursday forenoon a great deal of rain fell, and in the evening so much snow as to cover the ground. It snowed again on Friday, and on Saturday morning it snowed steadily for three hours, the wind about west-southwest. * * *

TABLE 1.—*Temperature records of notably cold seasons.*

Stations.	Year.	April.		May.		June.		July.		August.		Sept.	
		Mean.	Departure.	Mean.	Departure.	Mean.	Departure.	Mean.	Departure.	Mean.	Departure.	Mean.	Departure.
		°	°	°	°	°	°	°	°	°	°	°	°
Brunswick, Me.	1816	40.7	−1.9	48.8	−3.7	55.9	−6.4	61.9	−5.5	63.2	−2.4	55.7	−2.6
Do.	1857	44.3	+1.7	53.8	+1.3	60.7	−1.6	65.2	−2.2	60.8	−4.8	55.4	−2.9
Do.	1859	37.4	−5.2	50.6	−1.9	55.8	−6.5	63.6	−3.8	62.3	−3.3	52.8	−5.5
Lewiston, Me.	1907	39.6	−3.0	49.4	−3.1	...	...	...	...	...	...	...	...
Cambridge, Mass.	1816	44.2	−0.2	52.2	−3.8	61.3	−5.4	65.9	−6.0	67.4	−2.4	57.6	−4.3
Do.	1857	41.8	−2.6	54.7	−1.3	63.4	−3.3	71.6	−0.3	68.2	−1.6	62.0	+0.1
Do.	1859	42.9	−1.5	58.1	+2.1	63.1	−3.6	69.6	−2.3	68.0	−1.8	58.8	−3.1
Chestnut Hill, Mass.	1907	44.0	−0.4	53.7	−2.3	...	...	...	...	...	...	...	...
New Bedford, Mass.	1816	43.1	−1.4	51.8	−2.9	58.8	−5.1	63.6	−5.8	66.0	−2.1	58.5	−3.4
Do.	1857	41.2	−3.3	53.6	−1.1	62.4	−1.5	69.6	+0.2	68.0	−0.1	61.3	−0.6
Do.	1859	43.7	−0.8	55.2	+0.5	62.8	−1.1	68.2	−1.2	67.7	−0.4	59.5	−2.4
Do.	1907	42.5	−2.0	51.4	−3.3	...	...	...	...	...	...	...	...
New Haven, Conn.	1816	42.3	−4.6	52.0	−5.0	60.3	−6.8	65.0	−5.0	67.6	−2.8	57.6	−5.0
Do.	1857	43.2	−3.7	53.5	−3.5	62.0	−5.1	70.2	+0.2	68.8	−1.6	60.3	−2.3
Do.	1859	45.4	−1.5	57.4	+0.4	64.0	−3.1	68.1	−1.9	67.7	−2.7	59.1	−3.5
Do.	1907	43.4	−3.5	58.2	+1.2	...	...	...	...	...	...	...	...
Williamstown, Mass.	1816	42.7	−0.9	52.8	−3.0	60.8	−4.7	64.6	−5.0	64.9	−1.6	55.0	−3.8
Do.	1857	39.2	−4.4	53.5	−2.3	61.5	−4.0	69.7	+0.1	65.2	−1.3	58.2	−0.6
Do.	1859	40.8	−2.8	58.8	+3.0	61.9	−3.6	66.1	−3.5	58.8	−7.7	55.1	−3.7
Do.	1907	40.2	−3.4	50.8	−5.0	...	...	...	...	...	...	...	...
Morrisville, Pa.	1816	47.0	−3.4	57.0	−5.0	64.0	−6.7	68.0	−6.7	66.0	−6.1	62.0	−3.6
Do.	1857	43.1	−7.3	57.7	−4.3	66.2	−4.5	71.5	−3.2	70.0	−2.1	63.5	−2.1
Do.	1859	47.4	−3.0	61.0	−1.0	66.9	−3.8	71.6	−3.1	71.3	−0.8	62.1	−3.5
Beverly, N. J.	1907	47.0	−3.4	56.9	−5.1	...	...	...	...	...	...	...	...

This seems to have been the same storm referred to in a Quebec letter under date of July 10, 1816, in which the correspondent speaks of a week of snow and ice with driving northwest winds, June 7 to 10. This period of frigidity was reported to have been followed by a week of favorable weather, altho the season was then about three weeks backward, and the exportation of grain from Canada had been prohibited until September 10.

The month of July was colder than any July since that time, but there appears to have been sufficient heat for the ripening of wheat and rye. The latter part of June also probably furnished a number of days of summer heat. August was likewise a cool month, but the deficiency of temperature was hardly half as much as in July. September was nearly normal, and by October normal weather prevailed, after five consecutive months of cool weather. The records established in 1816 for June and July stand for all stations, except Brunswick, Me., at which place June and August, 1859, were colder than the corresponding months of 1816.

Predictions of famine thruout New England were freely made, and much alarm was felt over the situation. On July 17 reports from Pennsylvania and New Jersey showed that there would be about half a grass crop and very little corn. From Ohio came the cheering news, however, that altho the prospects were unfavorable at first the yield would far exceed expectation, and that notwithstanding the severe frosts considerable fruit would be saved. Maryland and Virginia also reported an excellent wheat crop, for which $1.50 per bushel was obtained.

On August 7, 1816, the Boston Recorder, commenting editorially on the outlook, said:

> In relation to the season, accounts from all parts of the country present an agreeable reversal of the gloomy reports which were made a few weeks since. Fruits of every description will be abundant. All kinds of grain, except corn, are more promising than in ordinary seasons.

It is evident from the foregoing that 1816 was not such a calamitous year as has been supposed.

The meteorological conditions which caused the cool weather can only be surmised. It is interesting to note, however, that in one other year the temperature sank as low in New England as in 1816; thus in 1787 the temperature at New Haven, Conn., in June sank to 35°, the same as in 1816. June frosts occurred at New Haven in the following-named years, including 1816:

1806, June 4, frost, temperature 40°.
1816, June 11, frost, temperature 35°.
1843, June 2, frost, temperature 36°.
1859, June 12, frost, temperature 37°.
1864, June 11, slight frost, temperature 41°.

The cold April and May of 1857.—Passing down the line of years from 1816 it will be found that the next pair of consecutively cold months occurred in 1857. As a cold month, April of that year has not been surpast in many places during the last ninety odd years. This is especially true of the upper Mississippi Valley, where the April mean temperature in 1857 at Fort Snelling, Minn., was but four-tenths of a degree above the freezing point, or nearly 5° below the April mean of 1907. The month of May, 1857, was not so cold as May, 1907. In the eastern part of the country the month last named was 4° to 8° colder than May, 1857. Considering the entire period, April 1–May 31, there is little difference between the two years.

So far as can now be ascertained, the effect of the cold weather of April and May, 1857, on the crops was not especially injurious. Some cornfields were replanted, since a lack of heat and excessive rains in the latter part of May caused the seed to rot in the ground. June and the summer months following were warm, and, unlike the present year, the warm weather began June 1, instead of the 15th. A good crop was produced, altho the yield of fruit was somewhat less than the ordinary.

The great frosts of June 5 and 11, 1859.—Two years after the cold spring of 1857, in what had thus far been a normal season, a change of temperature in a single night spread destruction over a large proportion of the wheat fields from eastern Iowa to New York. The corn crop and a great part of the garden truck in the same districts were killed. A killing frost, coming at a time when the wheat was generally considered as past all danger from freezing, overwhelmed the country with astonishment. The areas affected by this destructive freeze were eastern Iowa and Minnesota, northern and central Indiana and Illinois, Wisconsin, Ohio, Michigan, all of Pennsylvania and New York, except the southeast portions, and northern New England. In some localities thin ice was formed in vessels and stagnant pools. The frost of June 11 was not so severe as that of the 5th and 6th. The weather in the west turned cold on the 3d, and the low temperatures continued thruout the 4th with a heavy frost west of the Alleghenies on the morning of the 5th, and to the eastward on the morning of the 6th. Much of the wheat, being in full head and the grain in the milk, was ruined. The peach and apple crop was only partially destroyed. The corn that was but a few inches above ground recovered from the injury and produced a fair crop. The corn that had attained a height of 12 to 18 inches was replanted. Fortunately, the autumnal frosts did not occur until about the close of October, and the replanted fields were fully matured.

In 1874 and 1875 April and May were both deficient in temperature, April especially, but not so markedly as in 1857 or 1907. Wheat in 1874 was a good crop, the yield per acre in the spring wheat States being, however, lower than usual. The corn crop was 82,000,000 bushels less than the crop of 1873. Only a portion of this reduction can be charged to the cold weather and frost, since it was also injured by local droughts and the depredations of the chinch bugs, especially in the west. Conditions were unfavorable for a large crop of oats, but it is impossible to state the effect of the backward weather in the spring.

The average yield of corn per acre in 1874 was low, viz, 20.7 bushels, and the price was high, 64.7 cents per bushel. In 1875 the rate of yield was increased to 29.4 bushels per acre, but the price dropt to 42 cents. The average yield of wheat was reduced 1.3 bushels per acre, and while the aggregate quantity was 16,000,000 bushels less than in 1874, the aggregate value was about $3,500,000 more.

The oat crop was large and the price correspondingly low. The barley, potato, and cotton crops were excellent and prices low.

From the foregoing it would seem that the chance of injury to the staple crops of this country by reason of a backward spring is rather remote, provided, of course, a sufficient amount of heat is supplied in June. In the notable summer of 1816 corn and hay were the only two crops that suffered serious injury, and that summer was the coolest of a century. Drought and heat are much more likely to make serious inroads on the crops than are the chilling blasts of April and May.

BARNES'S "ICE FORMATION WITH SPECIAL REFERENCE TO ANCHOR ICE AND FRAZIL."

By W. W. COBLENTZ. Dated Washington, D. C., June 17, 1907.

The present book by Prof. Howard T. Barnes, of McGill University, is the result of the need which has arisen for republishing the author's various papers on the formation of river ice. It is the story of the ice formation in the St. Lawrence River, and is of especial interest in connection with hydraulic development in the far North, where the winters are long and intensely cold.

The phenomena connected with the formation of river ice are very complex, and, in presenting the subject, the author has very wisely included the elementary notions concerning heat transfer.

The book is divided into eight chapters, which treat of—1, the physical laws governing the transfer of heat; 2, the physical constants of ice; 3, the formation and structure of ice; 4, sheet, frazil, and anchor ice; 5, precise temperature measurements; 6, river temperatures; 7, theories to account for frazil and anchor ice; 8, methods of solving the ice problem in hydraulic engineering work—e. g., steam and electric heating of penstocks, racks, etc., in hydraulic power plants.

In Canada, as well as other localities in high latitudes, three kinds of ice are observed, viz, sheet or surface ice, frazil, and anchor ice. *Surface ice* is found only in still water, and is caused by the loss of heat to the cooler atmosphere, by radiation and conduction from its surface. Thickening of the ice sheet takes place downwards by conduction and radiation of heat thru the ice to the air.

Frazil is the French-Canadian term for fine spicular ice, from the French for forge cinders which it is supposed to resemble. It is formed in all rivers or streams flowing too swiftly for the formation of surface ice. A dull, stormy day, with the wind blowing against the current, is productive of the greatest amount of frazil, which, like anchor ice, has a tendency to sink upon the slightest provocation, and to follow submerged channels until it reaches a quiet bay. Here it rises to the under side of the surface ice, to which it freezes, forming a spongy growth, attaining great thickness; in some cases the author observed a depth of 80 feet of frazil.

Anchor ice, as the name implies, is found attached or anchored to the bottom of a river or stream, and often attains a thickness of 5 to 6 feet. It is also called ground ice, bottom ice, and ground-gru. In a shallow, smooth-flowing river we are more likely to have anchor ice formed in excess, whereas in a deep and turbulent stream we are likely to have more frazil. In a river 30 to 40 feet deep anchor ice is almost unknown, altho large quantities of frazil are met with.

We quote the following from Professor Barnes:

The various facts of common observation in connection with anchor ice point to radiation as the primal cause. Thus, it is found that a